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10CFR50.54 (f)

Docket Number 50-346

License Number NPF-3

Serial Number 3187

September 1, 2005

United States Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20551-0001

Subject: Davis-Besse Nuclear Power Station Response to NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors" (TAC No. MC4681)

Ladies and Gentlemen:

On September 13, 2004, the Nuclear Regulatory Commission (NRC) issued NRC Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors." The Davis-Besse Nuclear Power Station (DBNPS) initial response to this GL was provided on March 4, 2005 (DBNPS Serial Number 3128). Attachment 1 provides the DBNPS response to Item 2 of the requested information in GL 2004-02. Attachment 2 provides a comparison of the DBNPS design basis to the requirements of Regulatory Guide 1.82, Revision 3, "Water Sources for Long-term Recirculation Cooling Following a Loss of Coolant Accident." Attachment 3 provides a list of commitments made in this submittal.

If you have any questions or require further information, please contact Mr. Henry L. Hegrat, Supervisor - Fleet Licensing, at (330) 315-6944.

A116

The statements contained in this submittal, including its associated attachments, are true and correct to the best of my knowledge and belief. I declare under penalty of perjury that the foregoing is true and correct.

Executed on: September 1, 2005

By: Barry S. Allen for Mark B. Bezilla
Mark B. Bezilla, Vice President - Nuclear

DRB/s

Attachments:
1. Response to Requested Information Item 2 of Generic Letter 2004-02
2. Comparison of Regulatory Guide 1.82, Revision 3 Regulatory Position to Davis-Besse Nuclear Power Station Emergency Sump Strainer
3. Commitment List

cc: NRC/RIII Administrator
DB-1 NRC/NRR Project Manager
DB-1 Senior Resident Inspector
Utility Radiological Safety Board

Response to Requested Information Item 2 of NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors" Davis-Besse Nuclear Power Station, Unit 1 (DBNPS)

Introduction

NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," requests that Pressurized-Water Reactor (PWR) licensees provide information on the actions taken or planned to mechanistically evaluate the potential for the adverse effects of post-accident debris blockage and operation with debris-laden fluids to impede or prevent the recirculation functions of the Emergency Core Cooling System (ECCS) and Containment Spray System (CSS). This information was requested to be submitted no later than September 1, 2005. The Generic Letter states that any required physical modifications to the plant identified by the evaluation should be complete no later than December 31, 2007.

Davis-Besse has completed actions to address the issues identified in NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors." The mechanistic evaluation description is provided below. All modifications required due to the mechanistic evaluation were completed prior to plant restart from the Thirteenth Refueling Outage (13RFO, February 2002 through March 2004). Several activities to validate aspects of the evaluation are still in progress. This includes testing to quantify the impact of chemical effects on debris bed flow resistance. When final test results are available, the evaluation will be updated. These activities are further described below.

Each GL 2004-02 Item 2 topic is listed below, followed by the DBNPS response:

Request 2(a)

Confirmation that the ECCS and CSS recirculation functions under debris loading conditions are or will be in compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of this generic letter. This submittal should address the configuration of the plant that will exist once all modifications required for regulatory compliance have been made and this licensing basis has been updated to reflect the results of the analysis described above.

Response 2(a)

DBNPS confirms that the ECCS and CSS functions satisfy the requirements of 10 CFR 50.46 (b)(5) and 10 CFR 50, Appendix A, General Design Criteria 35, 38, and 41.

Compliance is based on substantive conformance with Regulatory Guide (RG) 1.82, Revision 3, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of Coolant Accident." Areas not in full compliance with that RG have been previously approved by the NRC. Attachment 2 to this letter provides additional detail on compliance with RG 1.82, Revision 3.

Response 2(c) below describes the final configuration of the plant. This information has been incorporated into the DBNPS current design and licensing basis, and has been appropriately included in the DBNPS Updated Safety Analysis Report.

Request 2(b)

A general description of and implementation schedule for all corrective actions, including any plant modifications, that you identified while responding to this generic letter. Efforts to implement the identified actions should be initiated no later than the first refueling outage starting after April 1, 2006. All actions should be completed by December 31, 2007. Provide justification for not implementing the identified actions during the first refueling outage starting after April 1, 2006. If all corrective actions will not be completed by December 31, 2007, describe how the regulatory requirements discussed in the Applicable Regulatory Requirements section will be met until the corrective actions are completed.

Response 2(b)

A mechanistic evaluation of the Davis-Besse containment, ECCS and CSS was performed. The evaluation included:

a) Containment walkdowns to identify and quantify debris sources,
b) Debris generation and transport analyses,
c) Net positive suction head margin analyses,
d) Emergency Sump Strainer structural analyses,
e) Evaluation and testing for downstream effects,
f) Interim qualitative assessment of margin to address integrated chemical effects.

Based on the evaluations and analyses, a new Emergency Sump Strainer was designed and installed. All plant modifications necessary to establish compliance with the Applicable Regulatory Requirements section have been completed. Detailed descriptions of methodologies used and the modifications completed are provided in Response 2(c), below.

Programmatic changes were previously implemented to maintain the design basis of the ECCS and CSS when they are required to be operable per plant Technical Specifications. This includes establishing controls on the types of materials that can be taken into containment; establishing requirements on what can be stored in containment; specifying coatings and insulation that can be used in containment; and verifying that the design basis is met prior to declaring the systems operable.

Part of the DBNPS sump improvement effort during 13RFO included evaluation of downstream effects of debris-laden water. After evaluating the downstream systems and components, and identifying components of concern, a test program was initiated to develop resolutions. Testing was performed utilizing representative materials and component configurations to assure realistic results were obtained. Based on the test results, several plant modifications were completed to ensure that systems would remain functional in the presence of debris-laden fluid. The modifications are described in Response 2(c), below.

DBNPS intends to participate in testing that demonstrates that the Zone of Influence modeled in the qualified coatings debris generation calculations is based on representative test results. This testing is expected to be complete by March 31, 2006. Incorporation of the results into calculations will be completed by June 30, 2007.

DBNPS is also monitoring the joint government and industry sponsored Integrated Chemical Effects Testing and follow-on testing to develop a head loss correlation. When the results of the testing become available, they will be assessed to ensure there is no impact on plant operation. Incorporation of the results into calculations will be completed by June 30, 2007. An interim qualitative assessment of margin to address chemical effects is included in Response 2(d)(iii), below.

Request 2(c)

A description of the methodology that was used to perform the analysis of the susceptibility of the ECCS and CSS recirculation functions to the adverse effects of post-accident debris blockage and operation with debris-laden fluids. The submittal may reference a guidance document (*e.g.*, Regulatory Guide 1.82, Rev. 3; industry guidance) or other methodology previously submitted to the NRC. (The submittal may also reference the response to Item 1 of the Requested Information described above. The documents to be submitted or referenced should include the results of any supporting containment walkdown surveillance performed to identify potential debris sources and other pertinent containment characteristics.)

Response 2(c)

The DBNPS undertook resolution of Generic Safety Issue (GSI) 191 as part of the containment recovery effort in 13RFO. At that time, no established resolution methodology existed. The methods applied at the DBNPS were similar to those presented in Regulatory Guide (RG) 1.82, Revision 2, with modification as needed to address Pressurized Water Reactor construction. Since RG 1.82, Revision 3, has now been issued and since it contains updated information for Pressurized Water Reactors, it has been used to evaluate the design for the DBNPS. A detailed evaluation of conformance with RG 1.82, Revision 3, is provided in Attachment 2.

The methodology utilized to determine the susceptibility of the ECCS and CSS recirculation functions to adverse effects of post-accident debris blockage and operation with debris-laden fluids was comprised of several activities. These activities were:

1) Identification of the containment debris source term.
2) Debris generation and transport analyses.
3) Analysis of Net Positive Suction Head (NPSH) Available and Required during applicable post-accident conditions.
4) Design of a new Containment Emergency Sump Strainer.
5) Evaluation of downstream effects of debris-laden water
6) Establishing controls to protect the design basis of the ECCS and CSS recirculation function. This item is fully discussed in Response 2(f).
7) Interim qualitative assessment of margin to accommodate integrated chemical effects.

Plant modifications, programmatic changes, and general containment work activities were undertaken to implement the results of the evaluations.

Containment walkdowns were utilized to identify the debris source term to be used in the evaluations. The walkdowns were conducted in accordance with procedure EN-DP-01507, "Containment Walkdown for Potential Sump Screen Debris Sources." This procedure was based on Nuclear Energy Institute Document NEI 02-01, Rev. 0, "Condition Assessment Guidelines: Debris Sources Inside PWR Containments," April 2002. An evaluation of Revision 1 of the NEI document was performed to assure that it did not identify any areas beyond that covered by EN-DP-01507. No outstanding issues were identified. All personnel that performed the walkdowns were trained in class ESC-CH-01, "Containment Health Lesson Plan: Emergency Sump Inspection" prior to conducting the walkdowns. The walkdowns utilized design drawings to identify potential debris sources. These sources were verified during the walkdowns, and any undocumented sources identified. Discrepancies were documented in the Corrective Action program. The results of the walkdowns were documented in Enercon Report DBE004-RPT-005 (ACT 03-0160), "Report on Davis Besse Walkdowns for Insulation and Debris Inside Containment Building in Support of the Emergency Sump Action Plan." The inventory of containment coatings was addressed as a separate issue throughout the debris source term identification phase, with its own governing procedures and processes. However, the results were included in the debris generation and transport analyses and the sump strainer design.

The debris generation analysis was based on NEDO-32686, Rev. 0, "Utility Resolution Guidance Document for ECCS Suction Strainer Blockage," with modification as needed to recognize PWR construction. The results of the debris generation analysis is documented in Enercon Report DBE004-RPT-001 (ACT 03-0159), "Determination of Post-LOCA Debris Generation for Design of Emergency Sump Strainer." The zone of influence (ZOI) used in debris generation varied based on the debris source. For reflective metal insulation and fibrous insulation, it was assumed that the entire sub-compartment (i.e., the D-Ring or the reactor vessel cavity) was the ZOI. The sub-compartments within the containment are sufficiently segregated so that no interaction would occur. DBNPS has no calcium silicate insulation that would become part of the post-LOCA debris source term. For qualified coatings the ZOI was considered to be conical in shape, based on the DBNPS Updated Safety Analysis Report. All unqualified coatings within containment were assumed to fail, either due to jet impingement or subsequent chemical spray.

Debris transport analysis was performed in two steps. First, the debris transport fractions for the two bounding accident scenarios were determined. The transport fraction analysis methodology was based on NUREG/CR 6762, Vol. 4, "GSI-191 Technical Assessment: Development of Debris Transport Fractions in Support of the Parametric Evaluation." Davis-Besse does not require establishment of ECCS recirculation via the emergency sump for any accidents other than Loss of Coolant Accidents (LOCAs). The bounding scenarios for the transport analyses were determined to be a double-ended break of the Reactor Coolant System (RCS) hot leg in the east D-ring of containment and a double ended rupture of one of the RCS nozzles entering the Reactor Vessel in the vessel annulus space. The east D-ring was selected due to the relatively large amount of fibrous insulation in that D-ring at the time of analysis. The annulus area was a separate scenario due to the potential for losing the lower sump strainer integrity and the lower debris generation that occurs due to the surrounding concrete structure. Once the fraction of generated debris entering the post-LOCA containment pool was determined, the debris transport within the pool was analyzed. This analysis used the methodology of NUREG/CR 6772, "GSI-191: Separate Effects Characterization of Debris Transport in Water." The analysis was performed as a computational fluid dynamics (CFD) analysis using the computer program FLOW-3D, to assess the potential for the debris to slide across the floor or to stay in suspension and be carried to the Emergency Sump strainer. These analyses were performed by Enercon Services, Inc. and Alion (ITS), Inc. Consideration of removal of sliding debris by trash racks installed around the periphery of the containment, perpendicular to the recirculation flow direction was included. Sensitivity analyses performed as a part of the debris head loss calculation demonstrated that a uniform distribution of the debris on the strainer resulted in the worst head loss across the debris. Even with all the transported fiber spread uniformly on the strainer surface, there is an insufficient amount to create the thickness required to observe the so-called "thin bed effect."

Latent debris loading in containment was included in the debris source term. The quantities of latent debris types were based upon the results of applying the Boiling Water Reactor Owners Group (BWROG) report NEDO-32686, "Utility Resolution Guidance Document for ECCS Suction Strainer Blockage," to the Perry Nuclear Power Plant (PNPP). The quantities included in the DBPNS analyses were scaled upward in recognition that the DBNPS containment volume and internal horizontal surface area is greater than PNPP. An aggressive containment cleaning effort was initiated during 13RFO to provide confidence that the actual latent debris load of containment was bounded by the assumed values. Containment cleanliness is confirmed prior to resuming plant operation as part of establishing containment integrity.

Determination of the NPSH available and the NPSH required for operation involved several calculations. The methods used were standard hydraulic analyses using Crane Technical Paper 410 and *Flow Resistance: A Design Guide for Engineers*, by Idelchik, Fried, and Erwin. The conservative minimum water level in containment post-LOCA was calculated. This considered both the level at switch over to recirculation and long-term, to account for volume changes due to cooldown. The head loss through the strainer structure and the ECCS and CSS piping due to maximum flow conditions was determined. The NPSH required was based on the flow through the system plus recirculation flow through the pumps. The calculations determined the maximum allowable head loss that the debris bed could contribute. In comparing this value to the head loss calculated for the established debris load, it was found that adequate positive NPSH margin always exists. The head loss associated with the debris bed was calculated using NUREG/CR 6224, "Parametric Study of the Potential For BWR ECCS Strainer Blockage Due to LOCA Generated Debris."

The strainer included in the above analyses was the new strainer installed during 13RFO. The strainer was designed to the standards of the DBNPS Design Criteria Manual. It included consideration of static and dynamic loading, such as seismic loads and flow-induced loads including loads due to the presence of the debris on the strainer surface. The material of construction was stainless steel so that the post-LOCA chemical environment would have no impact on strainer integrity. The strainer consists of two portions. The upper section is comprised of 27 vertical cylinders that have strainer media installed on the outer surface and a concentric inner surface of strainer media. The media is stainless steel plate perforated with 3/16" (0.1875") diameter holes on 5/16" centers.

tubes then pass any incoming flow to a plenum located at the top of the in-core tunnel stairs. The parallel tubes are also strainer media that can allow flow into the sump. From the upper plenum, a hole through the emergency sump wall passes flow into the emergency sump. The opening is protected with additional strainer media (with larger holes than the tubes, but still below the maximum allowable) so that if the lower strainer integrity is lost due to debris from a vessel cavity LOCA, the water entering the sump will still be filtered. Because a large part of the lower strainer surface area is suspended above the floor, debris not held in suspension would not be able to be deposited on the surface, based on the CFD analyses.

Even with the strainer present, small particles will enter the ECCS and CSS fluid streams. A detailed analysis of the downstream components was conducted to identify points where flow paths might be affected by the debris-laden water. The only items of concern were:

a) the cyclone separators that supply cooling water to the Low Pressure Injection pumps and
b) the passages to the hydrostatic bearing of the High Pressure Injection Pumps.

Testing was performed on both items to identify configurations that supported long term operation in the post-LOCA debris environment. The plant modifications required to implement these results were completed as part of the 13RFO activities. As a result of this testing, it was decided to add cyclone separators to the Containment Spray Pump mechanical seal water supply lines.

DBNPS also undertook a debris source term reduction program during 13RFO. This effort included removing the majority of fibrous insulation from containment. Very small quantities of fiber could not be removed due to the requirements of the systems on which it is installed. A total of 0.9 ft^3 of fibrous insulation potentially available for transport remains installed in containment, in addition to the amounts assumed for latent fiber. The bulk of this material is actually contained, but it was all assumed to become a debris source. In addition, materials used in signs, labels, and tags were examined to ensure they would not become debris. Unacceptable materials were removed or replaced with acceptable materials. The containment was cleaned extensively to minimize the actual latent debris. The containment dome, which had experienced coating degradation, was stripped and re-coated with a qualified coating.

Once the design basis of the Emergency Sump strainer was established and implemented, it was necessary to establish programs that would preserve that design basis. Programmatic controls established for this purpose are fully described in the Response to Request Item 2(f), below.

The impact of chemical effects was identified as a potential source of increased head loss during the post-LOCA mission time of the ECC and CS systems. Due to the lack of test information during the design of the DBNPS strainer, no specific head loss term was included for chemical effects. The government and industry are currently sponsoring testing to develop the composition of the post-LOCA water chemistry. A test program to assess the impact of this chemistry on head loss and to develop an applicable correlation is planned for the second half of 2005. As discussed in Response 2(b), DBNPS will update calculations based on the final testing results, modified as needed to reflect the station construction, by June 30, 2007. In the interim, a qualitative assessment of the margin available to address the potential impact of chemical effects has been included in Response 2(d)(iii), below.

Request 2(d)

The submittal should include, at a minimum, the following information:

Request 2(d)(i)

The minimum available NPSH margin for the ECCS and CSS pumps with an unblocked sump screen.

Response 2(d)(i)

The limiting minimum available NPSH margin for the ECCS pumps occurs on Low Pressure Injection Pump 1. With an unblocked screen, the margin is 2.5 ft. The limiting minimum available NPSH margin for the CSS pumps occurs on Containment Spray Pump 2. With an unblocked screen, the margin is 4.4 ft.

These values are conservative because they utilize the minimum volume of water injected from the Borated Water Storage Tank, including associated instrument errors. The analyses are calculated using the worst case break location, do not credit containment overpressure, and utilize worst case flow values including pump recirculation flow.

Request 2(d)(ii)

The submerged area of the sump screen at this time and the percent of submergence of the sump screen (i.e., partial or full) at the time of switchover to sump recirculation.

Response 2(d)(ii)

The total strainer surface area is calculated to be 1226 ft^2. This is made up of 394 ft^2 in the upper strainer structure and 832 ft^2 in the lower strainer structure.

Both the upper and lower strainer structure are fully submerged at the time of switchover to sump recirculation for all scenarios.

Request 2(d)(iii)

The maximum head loss postulated from debris accumulation on the submerged sump screen, and a description of the primary constituents of the debris bed that result in this head loss. In addition to debris generated by jet forces from the pipe rupture, debris created by the resulting containment environment (thermal and chemical) and CSS washdown should be considered in the analyses. Examples of this type of debris are debonded coatings in the form of chips and particulates and chemical precipitants caused by chemical reactions in the pool.

Response 2(d)(iii)

The maximum head loss across the calculated debris bed on the Emergency Sump Strainer is approximately 1.6 ft. of water. This head loss is calculated utilizing NUREG/CR 6224. The debris generation is described in Response 2(c) above. The primary constituent of the debris is reflective metal insulation debris and coatings debris, both particulate and chips. Paint debris is the primary contributor to the debris head loss.

The size and shape of the debris was based on information from the Boiling Water Reactor Owners Group (BWROG) documentation (NEDO 32686). The quantities of blowdown related debris, miscellaneous debris, and unidentified material debris were also based on this document, with conservatively developed scaling factors to account for the much larger containment associated with DBNPS. The quantities of qualified and unqualified coatings were based on inventories conducted as a part of resolving coatings issues. Ties between the coatings inventory program and the Emergency Sump head loss calculation were established to assure that as inventories are revised, the results are evaluated for impact on the debris head loss calculation.

The DBNPS containment was extensively cleaned . The improvement gained by cleaning has not been factored into the calculations to provide margin beyond the design basis of the analysis. The cleaning efforts included identifying and removing materials such as tags, labels, and signs if their behavior in the post-LOCA environment could not be determined. The post-LOCA environment included radiation, maximum post-LOCA temperature steam and liquid, water, and chemical spray.

The debris bed head loss was examined with parametric studies to provide allowance for variation in debris terms. The impact of varying each term was evaluated and little impact was noted. There is very little fiber in containment so the thin bed effect is not significant. Chemical effects are not expected to have a significant impact on the head loss term, primarily due to the very low fiber content of the debris. Research on this issue is ongoing and will be followed to assure that this is confirmed once results are available. The entire strainer structure is built of stainless steel so there is no anticipated chemical impact on the integrity of the strainer surface. Reducing the temperature of the fluid resulted in a net NPSH margin improvement. Non-uniform deposition also was shown to be bounded by a uniform deposition.

The current maximum acceptable head loss across the debris bed is conservatively calculated to be 2.5 feet of water. The calculated maximum actual debris bed head loss is conservatively calculated to be approximately 1.6 feet of water. This provides 0.9 feet of water of margin. Chemical effects would have to increase the debris head loss by more than 50% before the margin would be exhausted. This available margin greatly exceeds the margin recommendations provided by the Nuclear Energy Institute Sump Performance Task Force for a plant using a trisodium phosphate pH buffer with fibrous insulation, which is comparable to the DBNPS configuration. DBNPS has a very small fiber load in containment. The presence of a fiber bed on the strainer appears to be a key component in the chemical effects impact on head loss. In view of the low fiber loading and the large amount of margin available, it is judged that the chemical effects will not adversely affect the long-term recirculation capability of DBNPS. As discussed in Response 2(b), this will be confirmed when reliable test results are available to develop a head loss correlation. This will be completed by June 30, 2007.

Request 2(d)(iv)

The basis for concluding that the water inventory required to ensure adequate ECCS or CSS recirculation would not be held up or diverted by debris blockage at choke points in containment recirculation sump return flowpaths.

Response 2(d)(iv)

The various flow paths for water to reach the emergency sump were studied to assure that all the water in containment is available to the post-accident pool. The horizontal platforms within the D-rings are constructed of open grating that allows water to flow to the bottom floor of the containment (565 ft. elevation). This is the level that pours into the sump. Outside the D-rings, the solid floors are separated from the wall of the containment vessel by a ring of deck grating around much of the circumference of the building. This allows water to drain down to the 565 ft. elevation. There are also drains in the floors that will also pass water to the lower levels. Water falling into the refueling canal will drain from the deep end of the canal to the normal containment sump. The normal sump will be filled and adding to the containment post-LOCA pool through grating that forms its lid. The drain line from the deep end of the refueling canal is protected by a trash rack (a box made of deck grating) that will prevent material that could plug the line from entering. Material that can move past the trash rack cage will fit through the pipe and will be transported to the normal sump. It is prevented from entering the Emergency Sump by the installed strainer.

The normal sump has a pipe connecting it to the emergency sump to permit draining of water to the normal sump, should any occur in the emergency sump during power operation. The floor drain entrance to this pipe inside the emergency sump has strainer media welded over it to prevent entry of debris into the sump. This line is not relied upon to feed the emergency sump, so its blockage would be inconsequential to the recirculation function.

Debris interceptors have been installed at several points on the periphery of the 565 foot elevation of containment, perpendicular to the ECCS flow. The debris interceptors in the main flow path have three distinct regions. They have a solid base plate, six inches tall. Above that, a smaller grate size (4 in. by 1-3/16 in.) is installed in the section of the interceptor that would approximately be submerged post-LOCA to remove debris from the flow path. The grating opens up to a larger mesh (3-9/16in. by 4 in.) above the approximate minimum submergence level. The height of the gate is above the maximum containment flood level. This configuration aids in removing debris sliding on the floor, or moving in the flow stream below the surface while providing a nearly unimpeded path near the surface of the water. This will allow water to move past the debris interceptor regardless of how much debris accumulates at its lower sections. Debris interceptors made of grating are also installed where the recirculating fluid passes under the fuel transfer tubes. This adds additional large debris removal capacity while ensuring a flow path is maintained.

Request 2(d)(v)

The basis for concluding that inadequate core or containment cooling would not result due to debris blockage at flow restrictions in the ECCS and CSS flowpaths downstream of the sump screen, (e.g., a HPSI throttle valve, pump bearings and seals, fuel assembly inlet debris screen, or containment spray nozzles). The discussion should consider the adequacy of the sump screen's mesh spacing and state the basis for concluding that adverse gaps or breaches are not present on the screen surface.

Response 2(d)(v)

An evaluation of all downstream systems and components was completed as a part of the Generic Safety Issue 191 resolution project. Enercon Report DBE004-RPT-004 (ACT 03-0426), "Assessment of Debris Size Acceptance on ECCS Components" determined that the cyclone separators that provide clean water to the Low Pressure Injection pump seals and the Containment Spray pump seals and the High Pressure Injection pump internal passages could be adversely impacted by debris. This report included the

Framatome evaluation of the fuel assembly debris screens. It was found that outside of the identified items, adequate flow through the fuel, the ECCS and the CSS would be maintained so that the core cooling and containment cooling functions would be accomplished.

Based on the findings of the Enercon Report, significant effort to demonstrate the capability of the affected components was undertaken. A test program that modeled the anticipated debris loading quantities and characteristics of the post-LOCA fluid was initiated to assess the impact of the environment on the equipment. Based on the results, it was determined that the amount of fiber in containment has to be strictly controlled. Modifications to eliminate nearly all fibrous insulation were initiated and completed prior to plant restart. The remaining amounts, which are unlikely to be dislodged by LOCA blow down, were none-the-less retained in the test fluid modeling and applicable analyses. Additional quantities of fiber were also included in the model to provide margin for latent fibrous material that may be inadvertently left in containment despite the diligent effort made to remove such material prior to power operation.

Based on the results of the testing, the cyclone separators and the High Pressure Injection pumps were modified to match the final, successful as-tested configuration. This test program ensures that the design basis of the containment matches the design basis of the downstream components. This work was completed prior to the restart from 13RFO. No further work is outstanding with respect to debris laden fluid effect on downstream components.

Prior to declaring the ECCS and CSS operable following an outage, close inspection of the sump and strainer are required. Internal cleanliness is confirmed via accesses into the structures of the sump and strainer. Detailed surface and structural inspection is required. Inspectors may confirm that any gaps are smaller than the specified acceptance criterion. Inspectors are required to have knowledge of the sump's design and construction. The inspection is performed in accordance with DB-SP-03134, "Containment Emergency Sump Visual Inspection."

<u>Request 2(d)(vi)</u>

Verification that close-tolerance subcomponents in pumps, valves, and other ECCS and CSS components are not susceptible to plugging or excessive wear due to extended post-accident operation with debris-laden fluids.

<u>Response 2(d)(vi)</u>

The response to this item is the same as the response to 2(d)(v). The verification of capability consisted of demonstration testing.

Request 2(d)(vii)

Verification that the strength of the trash racks is adequate to protect the debris screens from missiles and other large debris. The submittal should also provide verification that the trash racks and sump screens are capable of withstanding the loads imposed by expanding jets, missiles, the accumulation of debris, and pressure differentials caused by post-LOCA blockage under predicted flow conditions.

Response 2(d)(vii)

The upper portion of the DBNPS sump strainer is surrounded by a protective stainless steel cage made of stainless steel deck grating which keeps large pieces of debris from impacting the upper strainer media. Additionally, large pieces of debris are removed from the flow stream by debris interceptors located around the containment periphery. The entire upper sump strainer structure is protected from LOCA generated missiles and large pieces of debris by a concrete floor, ceiling, and walls. One terminal end of the Reactor Coolant System (RCS) is located within this protected area. If that pipe were to rupture, the jet would have impinged on the trash racks and strainer media of the upper sump. Consequently, a jet blast deflector shield was installed between the source pipe and the strainer. This would deflect the blast upwards so that it would not impact the strainer.

The lower strainer had the potential to be damaged by missiles generated by a rupture of the RCS piping at the nozzles entering the Reactor Vessel. The intensity of this break was so large that structural integrity of the lower strainer structure could not be assured. However, the total amount of debris generated in containment by a break in this area is lower than the debris generated by a rupture in a Containment D-ring. The lower strainer was assumed to fail due to missiles, so an additional strainer cage was added where the lower strainer feeds into the sump through the wall between the sump and the in-core tunnel stairway. Analyses were then performed to determine the pressure drop associated with the debris loading created by this scenario, with the reduced strainer surface area and reduced debris load. The results showed that the debris pressure drop would be less than the pressure drop determined for the break in the D-ring scenario. The additional strainer cage is recessed into the sump structure so that debris cannot impact it during the blowdown of the RCS.

The structure of the sump strainer and the trash racks has a design basis that includes all static and dynamic hydraulic loads that it could experience. This includes the pressure drop across the debris bed due to flow through the strainer. The flow assumed in the analysis exceeds the maximum flow expected during recirculation so that the pressure drop is conservative. The analysis shows that the strainer and trash racks are capable of withstanding all loads that could be placed upon it.

Request 2(d)(viii)

If an active approach (e.g., backflushing, powered screens) is selected in lieu of or in addition to a passive approach to mitigate the effects of the debris blockage, describe the approach and the associated analyses.

Response 2(d)(viii)

The DBNPS strainer is passive in nature, so that this item is not applicable.

Request 2(e)

A general description of and planned schedule for any changes to the plant licensing basis resulting from any analysis or plant modifications made to ensure compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of this generic letter. Any licensing actions or exemption request needed to support changes to the plant licensing basis should be included.

Response 2(e)

The design basis of the modified emergency sump strainer has been incorporated into the plant's current licensing basis. The DBNPS Updated Safety Analysis Report has been revised to include this information as part of the modification implementation process.

No additional licensing actions or exemption requests are needed to support the DBNPS resolution of the emergency sump strainer blockage issues.

Request 2(f)

A description of the existing or planned programmatic controls that will ensure that potential sources of debris introduced into containment (e.g., insulation, signs, coatings, and foreign materials) will be assessed for potential adverse effect on the ECCS and CSS recirculation functions. Addressees may reference their responses to GL 98-04, "Potential for Degradation of the Emergency Core Cooling System and the Containment Spray System after a Loss-of-Coolant Accident Because of Construction and Protective Coating Deficiencies and Foreign Material in Containment," to the extent that their responses address these specific foreign material control issues.

Response 2(f)

Once the design basis of the Emergency Sump Strainer and downstream components was finalized, it was necessary to establish or refine programs that would protect this design basis. Specifications that control the types of coatings that may be used in containment were upgraded, including requirements for a design engineer to evaluate new coatings and maintenance of an unqualified coatings inventory. The coatings design engineer has been included in the sump strainer effort and has the coating limitations specified in design documents to ensure compliance. Similarly, the types of materials that can be stored in containment are procedurally inventoried and controlled. The application of tags, labels, and signs in containment is controlled procedurally to ensure that they don't contribute to the design debris load. The types of insulation that can be used in containment were restricted in the applicable design specification to ensure that no unacceptable additional fiber loading or calcium silicate is introduced to containment.

Procedures to confirm that the plant is in conformance with the design basis prior to declaring the systems operable were upgraded or established. The procedures address the cleanliness inside the emergency sump boundary, the integrity of the sump boundary, the status of trash racks and jet shields, and the cleanliness of containment outside the emergency sump boundary. Once the containment and emergency sump have been declared operable, controls are established to preserve their integrity and conformance to the design basis.

To ensure that personnel understand the importance that cleanliness contributes to design basis compliance, site wide training was conducted. The training raised awareness of the Emergency Sump issue and informed personnel of actions they can take to assist in addressing the issue.

Attachment 2

Comparison of Regulatory Guide 1.82, Revision 3 Regulatory Position to Davis-Besse Nuclear Power Station Emergency Sump Strainer

R.G. Item No.	Regulatory Position	DBNPS Design
1.	Pressurized Water Reactors	
1.1	Features Needed To Minimize the Potential for Loss of NPSH	
	The ECC sumps, which are the source of water for such functions as ECC and containment heat removal following a LOCA, should contain an appropriate combination of the following features and capabilities to ensure the availability of the ECC sumps for long-term cooling. The adequacy of the combinations of the features and capabilities should be evaluated using the criteria and assumptions in Regulatory Position 1.3.	
1.1.1	ECC Sumps, Debris Interceptors, and Debris Screens	
1.1.1.1	A minimum of two sumps should be provided, each with sufficient capacity to service one of the redundant trains of the ECCS and CSS.	Exception. DBNPS only has one Emergency Sump. This is the original design configuration licensed by the NRC.
	Distribution of water sources and containment spray between the sumps should be considered in the calculation of boron concentration in the sumps for evaluating post-LOCA subcriticality and shutdown margins. Typically, these calculations are performed assuming minimum boron concentration and minimum dilution sources. Similar considerations should also be given in the calculation of time for Hot Leg Switchover, which is calculated assuming maximum boron concentration and a minimum of dilution sources.	Not applicable. Since DBNPS only has one sump, fed by a single pool, water distribution and boron distribution are not required. DBNPS does not utilize Hot Leg Switchover.

R.G. Item No.	Regulatory Position	DBNPS Design
1.1.1.2	To the extent practical, the redundant sumps should be physically separated by structural barriers from each other and	Exception. DBNPS only has one Emergency Sump. This is the original design configuration licensed by the NRC.
	from high-energy piping systems to preclude damage from LOCA, and, if within the design basis, main steam or main feedwater break consequences to the components of both sumps (e.g., trash racks, sump screens, and sump outlets) by whipping pipes or high-velocity jets of water or steam.	Comply. The ECC sump is protected by concrete walls, ceiling, and structure. A jet impingement shield was installed to protect the sump strainer from the potential failure of the Decay Heat bypass line. Main steam and main feedwater line breaks are not within the design basis of the ECC sump strainer. The lower strainer is generally protected from damage by concrete structures, however, debris from a break of a Reactor Vessel nozzle could generate missiles that could damage the lower strainer. The strainer surface integrity is maintained by an installed strainer surface inside the sump that filters flow coming from the lower strainer. It is protected so that the water entering the sump is always strained.
1.1.1.3	The sumps should be located on the lowest floor elevation in the containment exclusive of the reactor vessel cavity to maximize the pool depth relative to the sump screens.	Comply. Located on the 565 ft. elevation. Only the reactor vessel cavity and normal sump are lower within containment.
	The sump outlets should be protected by appropriately oriented (e.g., at least two vertical or nearly vertical) debris interceptors: (1) a fine inner debris screen and (2) a coarse outer trash rack to prevent large debris from reaching the debris screen.	Comply in substance. The upper strainer design incorporates a fine inner debris screen and course outer trash racks. The lower strainer is supported off the floor so that large debris can not reach it.

R.G. Item No.	Regulatory Position	DBNPS Design
	A curb should be provided upstream of the trash racks to prevent high-density debris from being swept along the floor into the sump. To be effective, the height of the curb should be appropriate for the pool flow velocities, as the debris can jump over a curb if the velocities are sufficiently high. Experiments documented in NUREG/CR-6772 and NUREG/CR-6773 have demonstrated that substantial quantities of settled debris could transport across the sump pool floor to the sump screen by sliding or tumbling.	Comply in substance. Debris interceptors are located in flow paths where debris would be swept along the floor to the Emergency Sump. Additionally, a trash rack surrounds the upper strainer on the 565 ft. elevation. The debris interceptors incorporate a solid plate six inches high at their base to provide this curb function. The trash rack has a lower solid support 2 inches high to act as a curb. The lower strainer assembly is mounted off the floor so material being swept long the floor can not enter, thereby eliminating the need for a curb.
1.1.1.4	The floor in the vicinity of the ECC sump should slope gradually downward away from the sump to further retard floor debris transport and reduce the fraction of debris that might reach the sump screen.	Exception. The new design did not change the Containment floor, which is approximately level. This is the original design configuration licensed by the NRC.
1.1.1.5	All drains from the upper regions of the containment should terminate in such a manner that direct streams of water, which may contain entrained debris, will not directly impinge on the debris interceptors or discharge in close proximity to the sump.	Comply. The containment structure prevents direct impingement of drains on the debris interceptors. The drain piping empties into the normal sump, which is below the flood level and is connected via a separate line to the emergency sump, such that direct impingement is not possible.

R.G. Item No.	Regulatory Position	DBNPS Design
	The drains and other narrow pathways that connect compartments with potential break locations to the ECC sump should be designed to ensure that they would not become blocked by the debris; this is to ensure that water needed for an adequate NPSH margin could not be held up or diverted from the sump.	Comply. Flow paths to the sump were evaluated for blockage and debris interceptors, designed to prevent blockage of water flow, while retaining debris, were installed. Additionally, the drain from the refueling canal is protected from blockage by a large cage/trash rack.
1.1.1.6	The strength of the trash racks should be adequate to protect the debris screens from missiles and other large debris.	Comply in substance. The sump strainer is protected by concrete walls and structure so the strainer trash rack will not be exposed to missiles. The strainer trash rack is made of heavy gauge grating, sufficient for the debris in the area. A jet impingement shield is installed to protect the strainer from blowdown from a failure of the Decay Heat Drop Line bypass line. The lower strainer is generally protected from damage by concrete structures, however, debris from a break of a Reactor Vessel nozzle could generate missiles that could damage the lower strainer. The strainer surface integrity is maintained by an installed strainer surface inside the sump that filters flow coming from the lower strainer. It is protected so that the water entering the sump is always strained.

R.G. Item No.	Regulatory Position	DBNPS Design
	Trash racks and sump screens should be capable of withstanding the loads imposed by expanding jets, missiles, the accumulation of debris, and pressure differentials caused by post-LOCA blockage under design-basis flow conditions. When evaluating impact from potential expanding jets and missiles, credit for any protection to trash racks and sump screens offered by surrounding structures or credit for remoteness of trash racks and sump screens from potential high energy sources should be justified.	Comply in substance. The sump strainer is protected by concrete walls and structure so the trash rack will not be exposed to missiles. The structural analysis of the strainer and trash rack included static loads imposed by maximum ECC flow with the debris in place and hydrodynamic loads from a seismic event. A break of a reactor coolant line in the reactor vessel cavity could generate missiles, which could damage the lower strainer. For this break scenario, the upper strainer is designed to provide adequate flow with all the associated debris loading. A jet impingement shield was installed to protect the upper strainer for a possible failure of the Decay Heat Drop Line bypass line.
1.1.1.7	Where consistent with overall sump design and functionality, the top of the debris interceptor structures should be a solid cover plate that is designed to be fully submerged after a LOCA and completion of the ECC injection. The cover plate is intended to provide additional protection to debris interceptor structures from LOCA-generated loads.	Comply in substance. All horizontal surfaces of the upper strainer are solid plate. The strainer assembly is fully submerged for all potential breaks in which recirculation mode is required.
	However, the design should also provide means for venting of any air trapped underneath the cover.	Comply. The perforated plate used on all vertical surfaces will ensure any trapped air is vented.
1.1.1.8	The debris interceptors should be designed to withstand the inertial and hydrodynamic effects that are due to vibratory motion of a safe shutdown earthquake (SSE) following a LOCA without loss of structural integrity.	Comply. The new strainer design basis included seismic and hydrodynamic loads caused by a design basis SSE.

R.G. Item No.	Regulatory Position	DBNPS Design
1.1.1.9	Materials for debris interceptors and sump screens should be selected to avoid degradation during periods of both inactivity and operation and should have a low sensitivity to such adverse effects as stress-assisted corrosion that may be induced by chemically reactive spray during LOCA conditions.	Comply. The new strainer design uses stainless steel materials that resist degradation during inactive periods and resist degradation in the chemically reactive post-LOCA environment. Joints where stainless steel was attached to existing carbon steel structure were verified corrosion free and are large structures that will not lose integrity over the period of performance for the strainer post-LOCA. The joints are inspected at each containment close out to ensure that no corrosion exists to ensure the joint is still acceptable.
1.1.1.10	The debris interceptor structures should include access openings to facilitate inspection of these structures, any vortex suppressors, and the sump outlets.	Comply. All debris interceptor structures include openings to allow inspection, so that confirmation of structural integrity can be confirmed, that all vortex suppressors are intact, all piping is clear of debris, and the as-left configuration matches the as-designed configuration.
1.1.1.11	A sump screen design (i.e., size and shape) should be chosen that will avoid the loss of NPSH from debris blockage during the period that the ECCS is required to operate in order to maintain long-term cooling or maximize the time before loss of NPSH caused by debris blockage when used with an active mitigation system (see Regulatory Position 1.1.4).	Not applicable. DBNPS does not employ an active mitigation system.

R.G. Item No.	Regulatory Position	DBNPS Design
1.1.1.12	The possibility of debris-clogging flow restrictions downstream of the sump screen should be assessed to ensure adequate long term recirculation cooling, containment cooling, and containment pressure control capabilities. The size of the openings in the sump debris screen should be determined considering the flow restrictions of systems served by the ECCS sump. The potential for long thin slivers passing axially through the sump screen and then reorienting and clogging at any flow restriction downstream should be considered. Consideration should be given to the buildup of debris at downstream locations such as the following: containment spray nozzle openings, HPSI throttle valves, coolant channel openings in the core fuel assemblies, fuel assembly inlet debris screens, ECCS pump seals, bearings, and impeller running clearances. If it is determined that a sump screen with openings small enough to filter out particles of debris that are fine enough to cause damage to ECCS pump seals or bearings would be impractical, it is expected that modifications would be made to ECCS pumps or ECCS pumps would be procured that can operate long term under the probable conditions.	Comply in substance. Assessment of debris size and composition is included in the supporting design information documents for the sump strainer. The impact of debris that could pass through the strainer on downstream components was assessed and identified deficiencies were resolved separately. The resolutions were consistent with the strainer design basis. All downstream systems, structures and components are capable of fulfilling their design basis functions for the required duration post-LOCA. The sump strainer design assumes that the possibility of long slivers is not credible.

R.G. Item No.	Regulatory Position	DBNPS Design
1.1.1.13	ECC and containment spray pump suction inlets should be designed to prevent degradation of pump performance through air ingestion and other adverse hydraulic effects (e.g., circulatory flow patterns, high intake head losses).	Comply. All points of flow from the sump to the outlet pipes are bordered with vortex suppressors (1.5 inch deep floor grating) located greater than three diameters and at least six inches below the minimum sump water level. The selection and placement of vortex suppressors meets the guidance of Table A-6 of RG 1.82, Rev. 3, for design option #1 of a non-cubicle design.
1.1.1.14	All drains from the upper regions of the containment building, as well as floor drains, should terminate in such a manner that direct streams of water, which may contain entrained debris, will not discharge downstream of the sump screen, thereby bypassing the sump screen.	Comply. All floor drains, including the refueling canal deep end drain, terminate in the normal sump. That sump contributes to the overall containment pool outside the emergency sump strainer. The pipe that connects the emergency sump to the normal sump has strainer media in place so that all water entering the emergency sump has to pass through a strainer surface.

R.G. Item No.	Regulatory Position	DBNPS Design
1.1.1.15	Advanced strainer designs (e.g., stacked disc strainers) have demonstrated capabilities that are not provided by simple flat plate or cone-shaped strainers or screens. For example, these capabilities include built-in debris traps where debris can collect on surfaces while keeping a portion of the screen relatively free of debris. The convoluted structure of such strainer designs increases the total screen area, and these structures tend to prevent the condition referred to as the thin bed effect. It may be desirable to include these capabilities in any new sump strainer/screen designs. The performance characteristics and effectiveness of such designs should be supported by appropriate test data for any particular intended application.	Not applicable to the DBNPS design. The DBNPS design is made of simple shapes. The analysis of the debris bed head loss considered the "thin bed effect" and demonstrated through parametric studies that resulting head losses do not cause a loss of function.
1.1.2	Minimizing Debris	
	The debris (see Regulatory Position 1.3.2) that could accumulate on the sump screen should be minimized.	Comply. See Section 1.3.2.
1.1.2.1	Cleanliness programs should be established to clean the containment on a regular basis, and plant procedures should be established for control and removal of foreign materials from the containment.	Comply. Controls on the installation of new potential debris sources have been included in the design process. Procedures to control transient debris and to ensure the containment configuration is within the sump strainer design basis have been put in place. The containment configuration is confirmed prior to entering a operating mode where long term recirculation capability is required.

R.G. Item No.	Regulatory Position	DBNPS Design
1.1.2.2	Insulation types (e.g., fibrous and calcium silicate) that can be sources of debris that is known to more readily transport to the sump screen and cause higher head losses may be replaced with insulations (e.g., reflective metallic insulation) that transport less readily and cause less severe head losses once deposited onto the sump screen. If insulation is replaced or otherwise removed during maintenance, abatement procedures should be established to avoid generating latent debris in the containment.	Comply. DBNPS replaced the bulk of the fibrous insulation with reflective metal insulation during 13RFO. Following removal, extensive cleaning of the containment occurred to ensure the change-out did not result in additional latent debris in containment.
1.1.2.3	To minimize potential debris caused by chemical reaction of the pool water with metals in the containment, exposure of bare metal surfaces (e.g., scaffolding) to containment cooling water through spray impingement or immersion should be minimized either by removal or by chemical-resistant protection (e.g., coatings or jackets).	Exception. The amount of bare metal material in containment is in conformance with the original license condition of the plant. Addition of materials, such as stored scaffolding has been accomplished by placing the materials in boxes. The boxes have drain and vent holes drilled in them that are smaller than the holes of the strainer media so that any debris generated by chemical reaction will remain within the box. Chemical effect head loss testing, when complete will consider this material, as needed. The amount of fiber in containment has been greatly reduced so that the potential for thin bed effect impact has been reduced.
1.1.3	Instrumentation	

R.G. Item No.	Regulatory Position	DBNPS Design
	If relying on operator actions to mitigate the consequences of the accumulation of debris on the ECC sump screens, safety-related instrumentation that provides operators with an indication and audible warning of impending loss of NPSH for ECCS pumps should be available in the control room.	Not Applicable. DBNPS does not rely on operator action as the primary mitigation strategy. Preservation of adequate NPSH is the design basis of the plant.
1.1.4	Active Sump Screen System	
	An active device or system (see examples in Appendix B) may be provided to prevent the accumulation of debris on a sump screen or to mitigate the consequences of accumulation of debris on a sump screen. An active system should be able to prevent debris that may block restrictions found in the systems served by the ECC pumps from entering the system. The operation of the active component or system should not adversely affect the operation of other ECC components or systems. Performance characteristics of an active sump screen system should be supported by appropriate test data that address head loss performance.	Not applicable to DBNPS. The sump strainer is passive.
1.1.5	In-service Inspection	
	To ensure the operability and structural integrity of the trash racks and screens, access openings are necessary to permit inspection of the ECC sump structures and outlets. In-service inspection of racks, screens, vortex suppressors, and sump outlets, including visual examination for evidence of structural degradation or corrosion, should be performed on a regular basis at every refueling period downtime. Inspection of the ECC sump components late in the refueling period will ensure the absence of construction trash in the ECC sump area.	Comply. Access to inspect the inside the strainer surface is available. Access into the sump allows inspection of anti-vortex, piping end-bells, and suction piping. Access into the lower strainer allows inspection of the mid-strainer sections and the lower sections to assure integrity and cleanliness. The sump and strainer is inspected as part of the containment closeout process to minimize the potential for operation with an unacceptable configuration.

R.G. Item No.	Regulatory Position	DBNPS Design
1.2	Evaluation of Alternative Water Sources	
	To demonstrate that a combination of the features and actions listed above are adequate to ensure long-term cooling and that the five criteria of 10 CFR 50.46(b) will be met following a LOCA, an evaluation using the guidance and assumptions in Regulatory Position 1.3 should be conducted. If a licensee is relying on operator actions to prevent the accumulation of debris on ECC sump screens or to mitigate the consequences of the accumulation of debris on the ECC sump screens, an evaluation should be performed to ensure that the operator has adequate indications, training, time, and system capabilities to perform the necessary actions. If not covered by plant- specific emergency operating procedures, procedures should be established to use alternative water sources that will be activated when unacceptable head loss renders the sump inoperable. The valves needed to align the ECCS and containment spray systems (taking suction from the recirculation sumps) with an alternative water source should be periodically inspected and maintained.	Comply with requirement to perform analysis per Regulatory Position 1.3. Operator actions are not relied upon to mitigate the consequences of debris accumulation. The ECC suction strainer is adequately sized to ensure sufficient available NPSH. Alternate water supplies are not part of the mitigation strategy.
1.3	Evaluation of Long-Term Recirculation Capability	

R.G. Item No.	Regulatory Position	DBNPS Design
	The following techniques, assumptions, and guidance should be used in a deterministic, plant-specific evaluation to ensure that any implementation of a combination of the features and capabilities listed in Regulatory Position 1.1 are adequate to ensure the availability of a reliable water source for long-term recirculation following a LOCA. The assumptions and guidance listed below can also be used to develop test conditions for sump screens. Evaluation and confirmation of (1) sump hydraulic performance (e.g., geometric effects, air ingestion), (2) debris effects (e.g., debris transport, interceptor blockage, head loss), and (3) the combined impact on NPSH available at the pump inlet should be performed to ensure that long-term recirculation cooling can be accomplished following a LOCA. Such an evaluation should arrive at a determination of NPSH margin calculated at the pump inlet. An assessment should also be made of the susceptibility to debris blockage of the containment drainage flow paths to the recirculation sump; this is to protect against reduction in available NPSH if substantial amounts of water are held up or diverted away from the sump. An assessment should be made of the susceptibility of the flow restrictions in the ECCS and CSS recirculation flow paths downstream of the sump screens and of the recirculation pump seal and bearing assembly design to failure from particulate ingestion and abrasive effects to protect against degradation of long-term recirculation pumping capacity.	Comply. See specific items below. Testing of air entrainment was performed as part of Regulatory Guide 1.82, Revision 3 configuration development. Davis-Besse meets the configuration conditions specified in the Regulatory Guide. Debris head loss estimates are based on NUREG/CR 6224 test results. Limited testing of the Davis-Besse strainer configuration has demonstrated flat plate test correlations used are conservative. Conservative calculations demonstrate NPSH available margin exists. Drainage paths were assessed and protected as needed to prevent water hold up. Downstream effects evaluation and testing were completed. HPI pump bearing and cyclone separator modifications were implemented to address debris laden water effects.

R.G. Item No.	Regulatory Position	DBNPS Design
1.3.1	Net Positive Suction Head of ECCS and Containment Heat Removal Pumps	
1.3.1.1	ECC and containment heat removal systems should be designed so that sufficient available NPSH is provided to the system pumps, assuming the maximum expected temperature of pumped fluid and no increase in containment pressure from that present prior to the postulated LOCA. (See Regulatory Position 1.3.1.2.) For sump pools with temperatures less than 212°F, it is conservative to assume that the containment pressure equals the vapor pressure of the sump water. This ensures that credit is not taken for the containment pressurization during the transient.	Comply. The design basis uses a containment pressure equal to the vapor pressure of the water in the sump. This is the original design basis licensed by the NRC. Excess NPSH is available when all head losses, including transported debris is included.
	For subatmospheric containments, this guidance should apply after the injection phase has terminated. For subatmospheric containments, prior to termination of the injection phase, NPSH analyses should include conservative predictions of the containment atmospheric pressure and sump water temperature as a function of time.	Not applicable to DBNPS.
1.3.1.2	For certain operating PWRs for which the design cannot be practicably altered, conformance with Regulatory Position 1.3.1.1 may not be possible. In these cases, no additional containment pressure should be included in the determination of available NPSH than is necessary to preclude pump cavitation. Calculation of available containment pressure and sump water temperature as a function of time should underestimate the expected containment pressure and overestimate the sump water temperature when determining available NPSH for this situation.	Not applicable to DBNPS.

R.G. Item No.	Regulatory Position	DBNPS Design
1.3.1.3	For certain operating reactors for which the design cannot be practicably altered, if credit is taken for operation of an ECCS or containment heat removal pump in cavitation, prototypical pump tests should be performed along with post-test examination of the pump to demonstrate that pump performance will not be degraded and that the pump continues to meet all the performance criteria assumed in the safety analyses. The time period in the safety analyses during which the pump may be assumed to operate while cavitating should not be longer than the time for which the performance tests demonstrate that the pump meets performance criteria.	Not applicable to DBNPS.
1.3.1.4	The decay and residual heat produced following accident initiation should be included in the determination of the water temperature. The uncertainty in the determination of the decay heat should be included in this calculation. The residual heat should be calculated with margin.	Comply. The peak post-LOCA containment water temperature was utilized in calculations. The peak temperature calculation contains conservatisms that bound the uncertainty. Additionally, calculations at a conservatively low, long-term temperature were also performed to assure the results bounded all conditions.
1.3.1.5	The hot channel correction factor specified in ANSI/HI 1.1-1.5-1994 should not be used in determining the margin between the available and required NPSH for ECCS and containment heat removal system pumps.	Comply. This standard was not applied to the DBNPS analysis.

R.G. Item No.	Regulatory Position	DBNPS Design
1.3.1.6	The calculation of available NPSH should minimize the height of water above the pump suction (i.e., the level of water on the containment floor). The calculated height of water on the containment floor should not consider quantities of water that do not contribute to the sump pool (e.g., atmospheric steam, pooled water on floors and in refueling canals, spray droplets and other falling water, etc.). The amount of water in enclosed areas that cannot be readily returned to the sump should not be included in the calculated height of water on the containment floor.	Comply. Hold up volumes were addressed in the containment water level calculation. Though no specific hold-up volume was identified, estimates for steam, wall condensation, piping fill volumes, spray volume, and other water volumes that could affect the flood height were included, resulting in minimum water levels. The volume to fill the RCS to the maximum height, including cooldown shrinkage, were included.
1.3.1.7	The calculation of pipe and fitting resistance and the calculation of the nominal screen resistance without blockage by debris should be done in a recognized, defensible method or determined from applicable experimental data.	Comply. Calculation used conservative methodology with flow resistance data from Crane and Idelchik.
1.3.1.8	Sump screen flow resistance that is due to blockage by LOCA-generated debris or foreign material in the containment which is transported to the suction intake screens should be determined using Regulatory Position 1.3.4.	Comply. The methods of evaluating debris transport to the strainer and the consequences of the debris on flow resistance were performed as described in Regulatory Position 1.3.4.

R.G. Item No.	Regulatory Position	DBNPS Design
1.3.1.9	Calculation of available NPSH should be performed as a function of time until it is clear that the available NPSH will not decrease further.	Comply in substance. Calculation of NPSH was performed at two points in time to ensure the bounding condition was identified. Many of the temporal aspects were eliminated from the process by assuming instantaneous debris generation, transport, and deposition. The calculations demonstrated an improving NPSH margin over time as the water density increased with cooldown. When combined with other known conservatisms, the continued long term recirculation function is assured.
1.3.2	Debris Sources and Generation	

R.G. Item No.	Regulatory Position	DBNPS Design
1.3.2.1	Consistent with the requirements of 10 CFR 50.46, debris generation should be calculated for a number of postulated LOCAs of different sizes, locations, and other properties sufficient to provide assurance that the most severe postulated LOCAs are calculated. The level of severity corresponding to each postulated break should be based on the potential head loss incurred across the sump screen. Some PWRs may need recirculation from the sump for licensing basis events other than LOCAs. Therefore, licensees should evaluate the licensing basis and include potential break locations in the main steam and main feedwater lines as well in determining the most limiting conditions for sump operation.	Comply in substance. Debris generation was evaluated for several break locations. The maximum break size was utilized in debris generation. The debris source term for each containment subcompartment included: a) All insulation in the sub-compartment as a target for damage. b) All unqualified coatings in the containment. c) Qualified coatings within a conical jet with an expansion area based on the largest Reactor Coolant pipe within the subcompartment. Sub-compartments primarily considered were: each D-ring and the Reactor Vessel cavity. Other sub-compartments were bounded by these compartments due to few large RCS pipes being present in them. LOCA is the only event at DBNPS requiring the long-term recirculation function.
1.3.2.2	An acceptable method for estimating the amount of debris generated by a postulated LOCA is to use the zone of influence (ZOI). Examples of this approach are provided in NUREG/CR-6224 and Boiling Water Reactor Owners' Group (BWROG) Utility Resolution Guidance (NEDO-32686 and the staff's Safety Evaluation on the BWROG's response to NRC Bulletin 96-03). A representation of the ZOI for commonly used insulation materials is shown in Figure 3.	Comply. The zone of influence and the subsequent jets are used to determine the amount, size, and distribution of debris for the new design. The methods described in NUREG/CR 6224 and NEDO-32686 were utilized to assess debris generation. Destruction of coatings conservatively used a zone of influence from a 36" hot leg break. This was based on the

R.G. Item No.	Regulatory Position	DBNPS Design
	- The size and shape of the ZOI should be supported by analysis or experiments for the break and potential debris. The size and shape of the ZOI should be consistent with the debris source (e.g., insulation, fire barrier materials, etc.) damage pressures, i.e., the ZOI should extend until the jet pressures decrease below the experimentally determined damage pressures appropriate for the debris source.	DBNPS Updated Safety Analysis Report Figure 3.6-1, Fluid Jet Geometry.
	- The volume of debris contained within the ZOI should be used to estimate the amount of debris generated by a postulated break. - The size distribution of debris created in the ZOI should be determined by analysis or experiments. - The shock wave generated during the postulated pipe break and the subsequent jet should be the basis for estimating the amount of debris generated and the size or size distribution of the debris generated within the ZOI. Certain types of material used in a small quantity inside the containment can, with adequate justification, be demonstrated to make a marginal contribution to the debris loading for the ECC sump. If debris generation and debris transport data have not been determined experimentally for such material, it may be grouped with another like material existing in large quantities. For example, a small quantity of fibrous filtering material may be grouped with a substantially large quantity of fibrous	Comply. The volumes available to become debris were based on walkdowns of the containment and inventories of coatings performed to address coatings issues. The size distribution of debris was based on NUREG/CR 6224. Due to the sub-compartment configuration, the ZOI for insulation was considered to be the entire sub-compartment, since the shock wave could affect all insulation in that area. All insulation was available as a target. Not all insulation was destroyed. Once the shock wave spreads due to exiting the sub-compartment, its ability to disrupt insulation is diminished.

R.G. Item No.	Regulatory Position	DBNPS Design
	insulation debris, and the debris generation and transport data for the filter material need not be determined experimentally. However, such analyses are valid only if the small quantity of material treated in this manner does not have a significant effect when combined with other materials (e.g., a small quantity of calcium silicate combined with fibrous debris).	
1.3.2.3	A sufficient number of breaks in each high-pressure system that relies on recirculation should be considered to reasonably bound variations in debris generation by the size, quantity, and type of debris. As a minimum, the following postulated break locations should be considered. - Breaks in the reactor coolant system (e.g., hot leg, cold leg, pressurizer surge line) and, depending on the plant licensing basis, main steam and main feedwater lines with the largest amount of potential debris within the postulated ZOI, - Large breaks with two or more different types of debris, including the breaks with the most variety of debris, within the expected ZOI, - Breaks in areas with the most direct path to the sump, - Medium and large breaks with the largest potential particulate debris to insulation ratio by weight, and - Breaks that generate an amount of fibrous debris that, after its transport to the sump screen, could form a uniform thin bed that could subsequently filter sufficient particulate debris to create a relatively high head loss referred to as the 'thin-bed effect.' The minimum thickness of fibrous debris needed to form a thin bed has typically been	Comply. The analytical model has breaks in appropriate locations to identify those that create the largest debris load on the new design. Two breaks were identified which bound the debris generation. - A large break LOCA in the east Steam Generator D-ring. With the break at a high elevation, the liquid released to containment is at a minimum, creating a conservatively low flood height. The D-ring with the largest debris generation source was utilized. The ZOI was taken as the entire east D-ring for insulation. This is also the break with the most direct path to the sump. - A large break LOCA inside the Reactor Vessel Cavity was also analyzed due to its potential for damaging the lower strainer, reducing the available strainer area. A second, protected strainer surface was installed in the

R.G. Item No.	Regulatory Position	DBNPS Design
	estimated at 1/8 inch thick based on the nominal insulation density (NUREG/CR-6224).	sump and included in all NPSH analyses. Due to the limited debris generation of this break, the upper strainer area alone was sufficient to provide adequate flow capacity. - Parametric studies were performed to assess the impact of different debris loadings, regardless of the debris generation term. This included evaluation of the thin bed effect. - Because of the assumptions made to maximize debris generation, such as assuming all fibrous insulation is available for transport to the pool and all unqualified coatings in containment fail, variation of break size would not increase the resulting head loss, as the worst case conditions were selected for analysis. There is insufficient fiber in containment to achieve a thickness needed to create the thin bed effect. This is a result of effort to minimize the fibrous insulation.

R.G. Item No.	Regulatory Position	DBNPS Design
1.3.2.4	All insulation (e.g., fibrous, calcium silicate, reflective metallic), painted surfaces, fire barrier materials, and fibrous, cloth, plastic, or particulate materials within the ZOI should be considered a debris source. Analytical models or experiments should be used to predict the size of the postulated debris. For breaks postulated in the vicinity of the pressure vessel, the potential for debris generation from the packing materials commonly used in the penetrations and the insulation installed on the pressure vessel should be considered. Particulate debris generated by pipe rupture jets stripping off paint or coatings and eroding concrete at the point of impact should also be considered.	Comply in substance. As a part of the new design, walkdowns identified potential debris sources, including fire protection materials, thermal insulation, or filters that are present when long term recirculation capability is required. The debris generation was based on the Zones of Influence described above. The reactor vessel insulation was considered in the Reactor Vessel Cavity break. Jet impingement damage on coatings and concrete were included in the debris generation.
1.3.2.5	The cleanliness of the containment during plant operation should be considered when estimating the amount and type of debris available to block the ECC sump screens. The potential for such material (e.g., thermal insulation other than piping insulation, ropes, fire hoses, wire ties, tape, ventilation system filters, permanent tags or stickers on plant equipment, rust flakes from unpainted steel surfaces, corrosion products, dust and dirt, latent individual fibers) to impact head loss across the ECC sump screens should also be considered.	Comply. As a part of the new design, walkdowns identified potential debris sources, including all insulation; painted surfaces; fire protection material, filters, and fibrous, cloth, plastic, or particulate materials that are present in containment during periods when the long term recirculation path is required to be operable. General cleanliness of the plant was also documented noting transient and latent debris (e.g., rust, dirt, dust, tape). Experimental data and analytical models were used to predict sizes of the postulated debris quantities and types.

R.G. Item No.	Regulatory Position	DBNPS Design
1.3.2.6	In addition to debris generated by jet forces from the pipe rupture, debris created by the resulting containment environment (thermal and chemical) should be considered in the analyses. Examples of this type of debris would be disbondment of coatings in the form of chips and particulates or formation of chemical debris (precipitants) caused by chemical reactions in the pool.	Partially Comply. As part of the debris generation analysis, all unqualified coatings were assumed to fail as a result of the initial jet forces or the long-term containment environment. The material was assumed available immediately. DBNPS has qualitatively assessed the impact of chemical effects based on NEI Sump Task Force guidance. Adequate NPSH margin exists such that there is reasonable assurance the DBNPS design will be acceptable when final quantitative results are available.

R.G. Item No.	Regulatory Position	DBNPS Design
1.3.2.7	Debris generation that is due to continued degradation of insulation and other debris when subjected to turbulence caused by cascading water flows from upper regions of the containments or near the break overflow region should be considered in the analyses.	Comply in substance. DBNPS has assumed all insulation, both reflective metallic insulation (RMI) and fibrous insulation, in the worst case subcompartment is available for debris generation. Transport is instantaneous rather than time dependent. All latent fiber assumed to be in containment is assumed available for transport to the strainer. The opposing D-ring does not have significant fibrous insulation (some is assumed for conservatism). RMI degradation from impingement by chemical spray is not expected. The cascading water flows do not impinge on RMI since collected water is transported to the lower levels via floor drains or by draining to the peripheral grating at the outer edge of the solid flooring of containment. No significant quantities of RMI exist in that area.
1.3.3	Debris Transport	

R.G. Item No.	Regulatory Position	DBNPS Design
1.3.3.1	The calculation of debris quantities transported from debris sources to the sump screen should consider all modes of debris transport, including airborne debris transport, containment spray washdown debris transport, and containment sump pool debris transport. Consideration of the containment pool debris transport should include (1) debris transport during the fill-up phase, as well as during the recirculation phase, (2) the turbulence in the pool caused by the flow of water, water entering the pool from break overflow, and containment spray drainage, and (3) the buoyancy of the debris. Transport analyses of debris should consider: (1) debris that would float along the pool surface, (2) debris that would remain suspended due to pool turbulence (e.g., individual fibers and fine particulates), and (3) debris that readily settles to the pool floor.	Comply. A complete transport analysis was performed. Detailed debris transport logic trees that determined how much debris reaches the containment pool based on NUREG/CR-6762, detailed Computational Fluid Dynamics (CFD) models were developed for the upper containment pool and the lower in-core tunnel. The analysis used the FLOW-3D CFD computer code. This code evaluates fluid turbulence as well as horizontal velocities to allow determination of what materials stay in solution as well as materials that slide across the floor. It includes modeling of water flow from break locations and water cascading from upper elevations.
1.3.3.2	The debris transport analyses should consider each type of insulation (e.g., fibrous, calcium silicate, reflective metallic) and debris size (e.g., particulates, fibrous fine, large pieces of fibrous insulation). The analyses should also consider the potential for further decomposition of the debris as it is transported to the sump screen.	Comply. The transport logic trees, the pool transport analyses, and the sump strainer head loss calculation evaluated each type of debris identified. In general, these analyses used the conservative values for characteristic size of debris. Parametric studies of impact on head loss were performed for each type of debris. This would simulate the potential decomposition of debris by adding to the initial estimated loading of the strainer by each debris type. The results showed that the associated head loss always stayed well within acceptable limits.

R.G. Item No.	Regulatory Position	DBNPS Design
1.3.3.3	Bulk flow velocity from recirculation operations, LOCA-related hydrodynamic phenomena, and other hydrodynamic forces (e.g., local turbulence effects or pool mixing) should be considered for both debris transport and ECC sump screen velocity computations.	Comply. The transport and CFD calculations considered the velocity patterns and turbulent kinetic energy (energy that keeps particulate matter suspended) distributions. Maximum recirculation flow rates were used, beyond those actually expected, based on plant design and operation.
1.3.3.4	An acceptable analytical approach to predict debris transport within the sump pool is to use computational fluid dynamics (CFD) simulations in combination with the experimental debris transport data. Examples of this approach are provided in NUREG/CR-6772 and NUREG/CR-6773. Alternative methods for debris transport analyses are also acceptable, provided they are supported by adequate validation of analytical techniques using experimental data to ensure that the debris transport estimates are conservative with respect to the quantities and types of debris transported to the sump screen.	Comply. CFD analysis was used to analytically quantify the transport of debris in the containment.
1.3.3.5	Curbs can be credited for removing heavier debris that has been shown analytically or experimentally to travel by sliding along the containment floor and that cannot be lifted off the floor within the calculated water velocity range.	Comply. Curbs and debris interceptors are credited in reducing the transport of materials that slide across the floor. Evaluation of potential to slide up the debris ramp formed at the curb was included to ensure conservative results.
1.3.3.6	If transported to the sump pool, all debris (e.g., fine fibrous, particulates) that would remain suspended due to pool turbulence should be considered to reach the sump screen.	Comply. All suspended material in the pool that had a continuous path of suspension to the strainer was considered to reach the strainer.

R.G. Item No.	Regulatory Position	DBNPS Design
1.3.3.7	The time to switch over to sump recirculation and the operation of containment spray should be considered in the evaluation of debris transport to the sump screen.	Comply. The time to switch over to recirculation was considered in evaluating temperature effects, however, the peak containment temperature was utilized, rather than the temperature at switchover because it gives conservative results. Maximum flow through the strainer was analyzed, including two ECC trains and two unthrottled Containment Spray trains in operation.

R.G. Item No.	Regulatory Position	DBNPS Design
1.3.3.8	In lieu of performing airborne and containment spray washdown debris transport analyses, it could be assumed that all debris will be transported to the sump pool. In lieu of performing sump pool debris transport analyses (Regulatory Position 1.3.3.4), it could be assumed that all debris entering the sump pool or originating in the sump will be considered transported to the sump screen when estimating screen debris bed head loss. If it is credible in a plant that all drains leading to the containment sump could become completely blocked, or an inventory holdup in containment could happen together with debris loading on the sump screen, these situations could pose a worse impact on the recirculation sump performance than the assumed situations mentioned above. In this case, these situations should also be assessed.	Not applicable. Debris transport analyses were performed. Not applicable. Pool debris transport analyses were performed. Not applicable. The floor drains have inlet screens over them preventing entry of materials that could block the pipe. Should the inlet become blocked, the water flows to the containment periphery, where it spills down to the pool level via grating that separates solid concrete deck from the containment vessel wall. A drain pipe leads from the refueling canal deep end to the normal sump. The drain line is protected by a debris interceptor. The interceptor will hold large debris away from the pipe inlet to that a flow path will be maintained. Once in the normal sump, the water is part of the containment pool, as the normal sump connects to the reactor cavity floor level through deck grating, which is submerged, post-LOCA.

R.G. Item No.	Regulatory Position	DBNPS Design
1.3.3.9	The effects of floating or buoyant debris on the integrity of the sump screen and on subsequent head loss should be considered. For screens that are not fully submerged or are only shallowly submerged, floating debris could contribute to the debris bed head loss. The head loss due to floating or buoyant debris could be minimized by a design feature to keep buoyant debris from reaching the sump screen.	Comply. The presence of debris interceptors around containment to the maximum flood height removes large floating debris. The trash rack surrounding the strainer media and solid tops of the strainer media strainer also eliminate the potential for buoyant or floating debris to affect the fully submerged vertical surfaces of the upper strainer by keeping the material away from the strainer media. Floating debris does not reach the lower strainer as it is well below the surface of the containment flood pool. Should the integrity of the lower strainer be challenged, an inner strainer is provided at the interface to the sump. That surface is protected by additional grating to protect the boundary integrity from debris damage.
1.3.4	Debris Accumulation and Head Loss	
1.3.4.1	ECC sump screen blockage should be evaluated based on the amount of debris estimated using the assumptions and criteria described in Regulatory Position 1.3.2 and on the debris transported to the ECC sump per Regulatory Position 1.3.3. This volume of debris should be used to estimate the rate of accumulation of debris on the ECC sump screen.	Comply. Regulatory Positions 1.3.2 and 1.3.3 were used to estimate the type and quantity of debris, as well as its transport to the sump strainer. This volume was used to estimate the debris accumulation on the strainer. A rate was not developed, rather all debris was assumed present at time of switchover to sump recirculation.

R.G. Item No.	Regulatory Position	DBNPS Design
1.3.4.2	Consideration of ECC sump screen submergence (full or partial) at the time of switchover to ECCS should be given in calculating the available (wetted) screen area. For plants in which containment heat removal pumps take suction from the ECC sump before switchover to the ECCS, the available NPSH for these pumps should consider the submergence of the sump screens at the time these pumps initiate suction from the ECC sump. Unless otherwise shown analytically or experimentally, debris should be assumed to be uniformly distributed over the available sump screen surface. Debris mass should be calculated based on the amount of debris estimated to reach the ECC sump screen. (See Revision 1 of NUREG-0897, NUREG/CR-3616, and NUREG/CR-6224.)	Comply. The minimum containment water level, including instrumentation uncertainties affecting when switchover occurs, is adequate to ensure full submergence of the strainer when recirculation is initiated. Debris was loaded uniformly across the strainer. Analyses demonstrated that this yielded the most conservative results. The proprietary code "HLOSS 1.0 A Code for the Prediction of ECCS Strainer Head Loss" was used in analysis.
1.3.4.3	For fully submerged sump screens, the NPSH available to the ECC pumps should be determined using the conditions specified in the plant's licensing basis.	Comply. The design assumptions of the DBNPS licensing basis were carried forward into the new design, with the exception of the head loss due to debris blockage which was updated from the 50% blocked assumption.
1.3.4.4	For partially submerged sumps, NPSH margin may not be the only failure criterion, as discussed in Appendix A. For partially submerged sumps, credit should only be given to the portion of the sump screen that is expected to be submerged, as a function of time. Pump failure should be assumed to occur when the head loss across the sump screen (including only the clean screen head loss and the debris bed head loss) is greater than one-half of the submerged screen height or NPSH margin.	Not applicable to DBNPS. The sump and strainer are fully submerged.

R.G. Item No.	Regulatory Position	DBNPS Design
1.3.4.5	Estimates of head loss caused by debris blockage should be developed from empirical data based on the sump screen design (e.g., surface area and geometry), postulated combinations of debris (i.e., amount, size distribution, type), and approach velocity. Because debris beds that form on sump screens can trap debris that would pass through an unobstructed sump screen opening, any head loss correlation should conservatively account for filtration of particulates by the debris bed, including particulates that would pass through an unobstructed sump screen.	Comply. The methodology used at BWRs was used, with modifications to address fundamental design differences, such as containment volume and strainer location outside a suppression pool.
1.3.4.6	Consistent with the requirements of 10 CFR 50.46, head loss should be calculated for the debris beds formed of different combinations of fibers and particulate mixtures (e.g., minimum uniform thin bed of fibers supporting a layer of particulate debris) based on assumptions and criteria described in Regulatory Positions 1.3.2 and 1.3.3.	Comply. The debris head loss calculation developed parametrics for changes in quantity of fiber and particulate matter, as well as evaluating the thin bed effect. This assures that regardless of how much material actually arrives at the strainer, the analyses are bounding and conservative, and strainer operability is assured.

COMMITMENT LIST

The following list identifies those actions committed to by the Davis-Besse Nuclear Power Station (DBNPS) in this document. Any other actions discussed in the submittal represent intended or planned actions by the DBNPS. They are described only for information and are not regulatory commitments. Please notify Henry L. Hegrat, Supervisor - Fleet Licensing at (330) 315-6944, of any questions regarding this document or any associated regulatory commitments.

COMMITMENTS	DUE DATE
DBNPS intends to participate in testing that demonstrates that the Zone of Influence modeled in the qualified coatings debris generation calculations is based on representative test results. This testing is expected to be complete by March 31, 2006. Incorporation of the results into calculations will be completed by June 30, 2007.	June 30, 2007
DBNPS is also monitoring the joint government and industry sponsored Integrated Chemical Effects Testing and follow-on testing to develop a head loss correlation. When the results of the testing become available, they will be assessed to ensure there is no impact on plant operation. Incorporation of the results into calculations will be completed by June 30, 2007.	June 30, 2007